Analogue Study of Geothermal Properties of the Rimbey-Meadowbrook Reef Trend in the Alberta Basin, Canada

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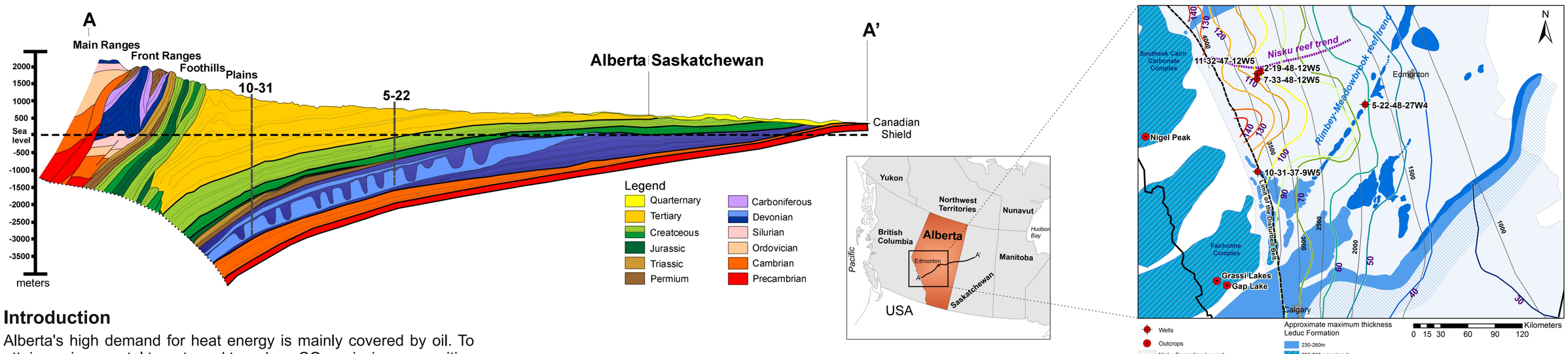


Fig. 1: Schematic cross section of the Alberta Basin and the Rocky Mountains on the left (modified from Price et al. (1994) and based on several cross sections from the Geological Survey of Alberta and Wright et al. (1994)).The light blue colour represents the Upper Devonian reef build ups of the Leduc Formation of the Rimbey-Meadowbrook Reef Trend and the overlying thinner Nisku Formation.The black numbers represent the investigated drillings of the Leduc Formation.The map on the right shows the extension of the Leduc Formation with approximate maximum thickness, projected vertically onto the map. The ice blue area stands for the extension of the overlying Nisku Formation (representing the Formation on top of the Winterburn Group, Upper Devonian). The formations outlines are based on Switzer et al. (1994). The coloured lines indicate temperatures on top of the Winterburn Group calculated from data derived from more than 26400 wells (Majorowicz & Weides, 2014).The black lines stand for the depth contour to top of the of Winterburn group.

Introduction

Alberta's high demand for heat energy is mainly covered by oil. To attain environmental targets and to reduce CO_2-emissions, a positive potential assessment will be appreciated to possibly provide geothermal energy as an alternative to fossil fuels. Recent studies using data from several ten thousands of drillings point out to the Upper Devonian carbonate systems (Majorowicz & Weides, 2014) for geothermal utilization. Previous studies hardly involve measurements of geothermal rock properties.

The MalVonian project's objective is to explore geothermal potentials of two carbonate aquifer systems, which – in spite of different ages – indicate similarities in tectonical structures and hydrogeological conditions. The project is in coorporation with University of Alberta and funded by DAAD.

The Upper Jurassic Malm aquifers within the Southern German Molasse Basin have already been well researched and proven to be suitable geothermal reservoirs, so far with 20 ongoing or completed projects (Bundesverband Geothermie, 2016). Reservoir exploration was accomplished by predominantly using the analogue study concept (e.g. Homuth et al., 2015). Analogue studies determine and correlate facies related rock properties of surface outcrops to facies related reservoir rocks. Experience from the completed projects within the Molasse Basin should then serve as reference for the exploration of up to now unexposed and potential reservoirs.

The Upper Devonian Leduc Formation within the west central part of the Canadian Alberta Basin has been exploited for oil production since the early 1950's. Outcrops containing rocks of stratigraphically equivalent formations are located in the Front Ranges of the Rocky Mountains.

This study focuses on the comparison between analogue and reservoir samples of the Devonian carbonate complexes of the Rimbey-Meadowbrook Reef Trend, serving as verification for the transcontinental analogue concept.

Material & Methods

To accomplish the analogue study acquiring geothermal and petrophysical rock properties, samples from 3 analogue outcrops and 5 cores of the target reservoir were used. Parameters like density, porosity, permeability, thermal conductivity, thermal diffusivity, heat capacity as well as wave velocities were measured on the analogue samples at the TU Darmstadt laboratory (Darmstadt).

For direct comparison with the target reservoir, thermal conductivity and permeability measurements were carried out on cores at the Calgary Research Center (CRC) and at the University of Alberta corelab (Edmonton).

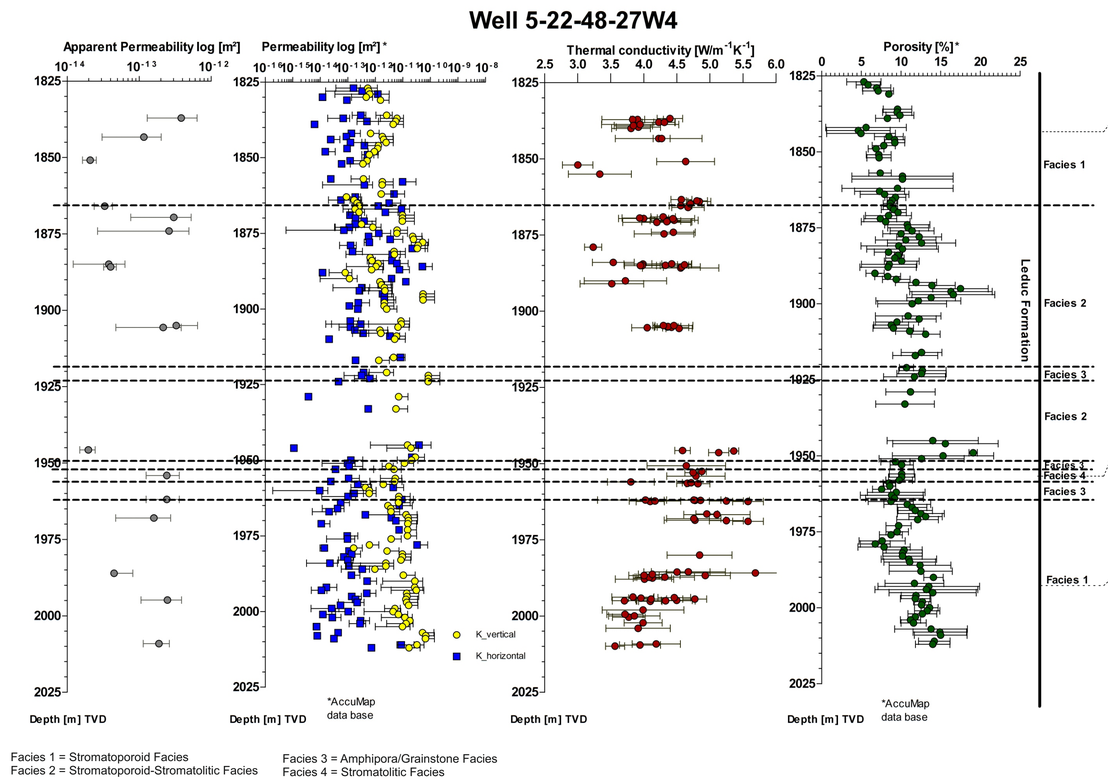


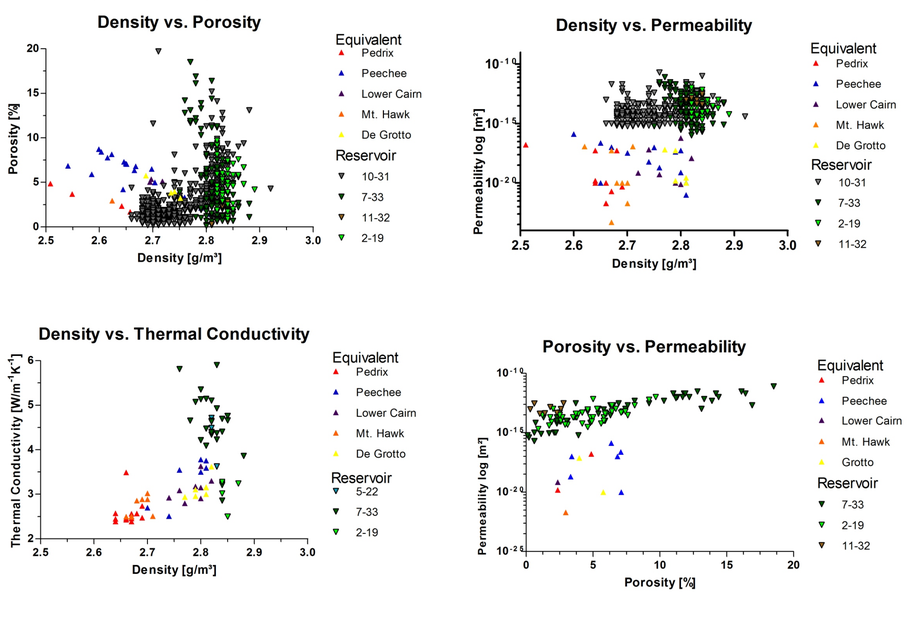
Fig. 2: Measurement results of apparent permeability and thermal conductivity from well 5-22-48-27W4 of the Leduc Formation in correlation with permeability and porosity measurements from the AccuMap data base. Facies were defined according to shape and size of the vugs and molds of the dissolved parts, classified by Drivet (1993). Exemplary core samples are shown on the right (depth: A and B = 1843.1 m; C and D = 1957 m and E and F = 1993.4 m).

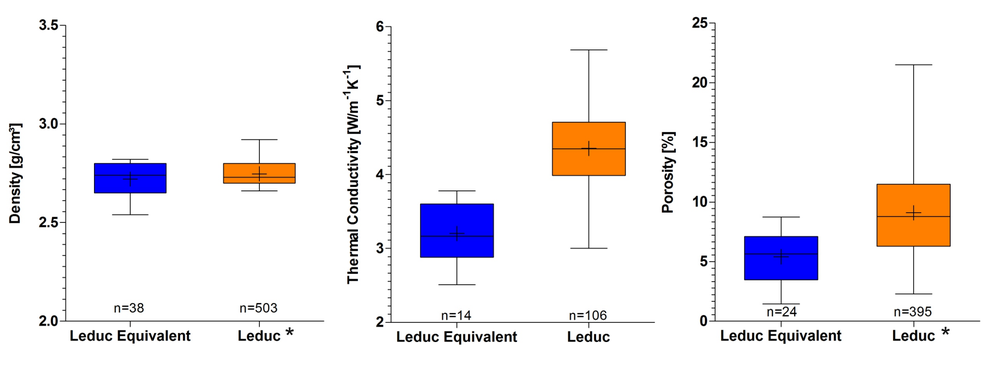
Results and Outlook

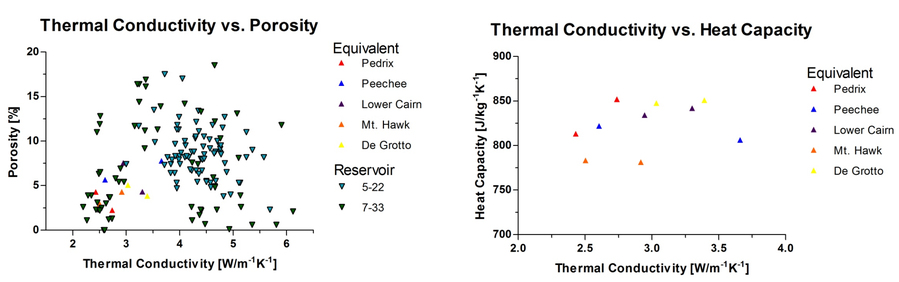
The Rocky Mountain's orogeny changed rock properties of the equivalent formations with respect to the reservoir. Diagenetic evolution and dolomitization seem to be major control factors and affect geothermal properties. The thermofacies concept (Sass & Götz, 2012) can obviously not be applied to analogue samples which underwent high deformation.

However, results from the reservoir samples indicate good conditions for geothermal utilization. Therefore additional investigations focus on hydrochemical and hydrogeological reservoir properties in combination with further measurements on reservoir samples.

For an upscaled adapted model recent comprehensive petrological and hydrological studies (e.g Kuflevskiy, 2015) should be correlated or integrated.







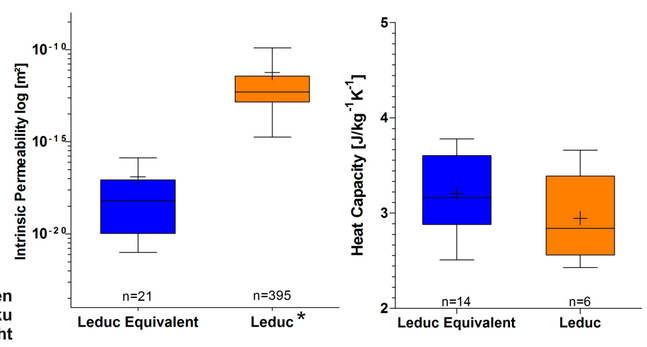


Fig. 3: Correlations of exemplary rock properties measured on the analogue and reservoir samples. Density, permeability and porosity measurements of the reservoir were taken from the AccuMap data base. The Peechee, Lower Cairn and Pedrix Formations represent the „Leduc Equivalent", whereby the Grotto and Mt. Hawk Formations stand for the „Nisku Equivalent". The Pedrix and Mt. Hawk Formations represent off-reef areas (dark grey, argillaceous limestones), whereby the remaining formations mainly contain dark grey to light grey dolostones. The wells 10-31 and 5-22 belong to the Leduc Formation of the Rimbey-Meadowbrook Reef Trend and the wells 7-33, 11-32 and 2-19 belong to the Nisku Reef Trend.

Fig. 4: Comparison of exemplary average rock properties of the Leduc Formation and the Leduc Equivalent in the Rocky Mountains.

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